A Numerical Model for Simulating Water Shutoff Operations in Porous and Fractured Reservoirs

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Abstract

A new numerical method is developed and implemented into a three-dimensional, three-phase reservoir simulator for modeling water shutoff operations in porous and/or fractured reservoirs. The model describes both Newtonian and non-Newtonian flow behaviors of oil, water and gas, coupled with advective, diffusive and adsorptive transport of chemicals (polymer or gel) as water shutoff agent within the aqueous phase. The water shutoff mechanisms incorporated include (1) reduction in aqueous-phase relative permeability and (2) increase in aqueous-phase viscosity due to presence of a water shutoff agent. A control-volume, integral finite difference method is used for spatial discretization, and a first-order finite difference scheme is adapted for temporal discretization of governing mass balance equations for the fluids and the chemical component. The resulting discrete non-linear equations are solved by Newton iteration with a fully implicit scheme or an adaptive implicit method (AIM). The simulator is applicable to simulations of oil and/or gas production from both heterogeneous single-porosity and fractured reservoirs.

The objective of this study presents a new modeling technique for simulating waterflooding and enhanced oil recovery processes with water shutoff operations and in particular for feasibility studies and optimal designs of such operations for oil reservoirs undergoing long-term waterflooding production. In addition, the simulator, equipped with coupled wellbore flow model using a virtual node approach, can handle various production and injection wells, including vertical, horizontal and inclined wells. Several verification and demonstration examples will be discussed.